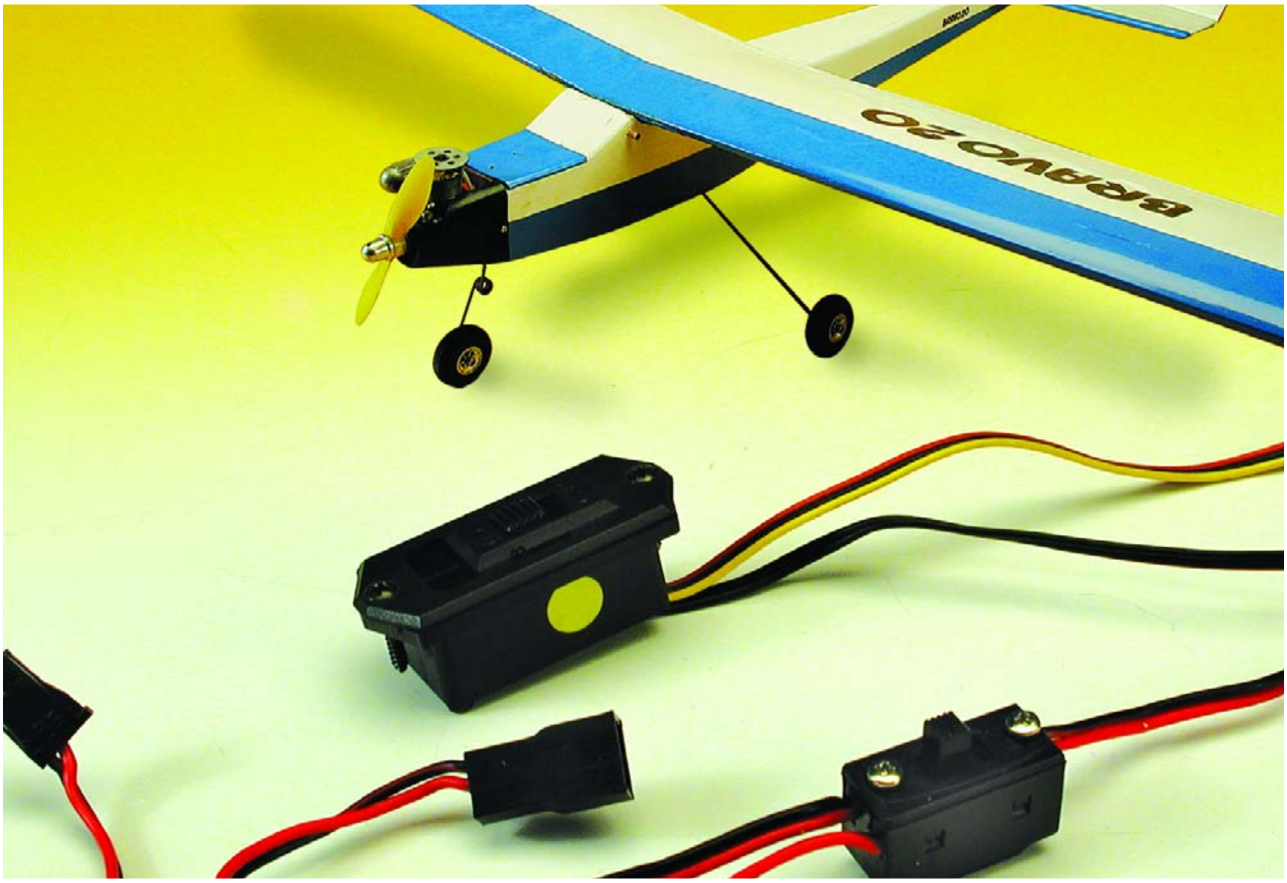
Electronic Switch for Modellers

Electronics instead of mechanics



Switching systems in models often suffer from mechanical problems. This electronic replacement is much more reliable and offers a little bit extra!

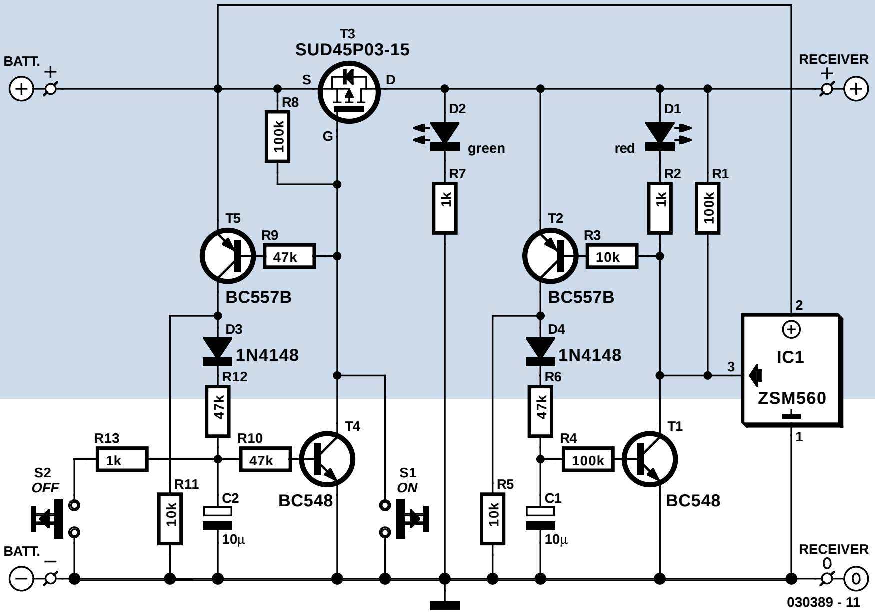
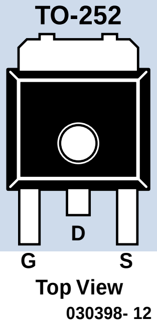


Figure 1. Circuit diagram of the electronic switching system.



Remote-controlled models include many components that, because of their various shortcomings, need to be checked constantly. The scale of the problem is clear from the number of different add-on units that are available from the various manufacturers. Here we present an extremely useful circuit that replaces the (often rather temperamental) switching harness and which also offers a voltage-monitoring function with memory.

Why replace the switch?

Experiments with mechanical switching systems reveal, surprisingly, that they have contact resistances typically between 0.3 Ω and 0.5 Ω. At a peak current of 1 A, which is by no means out of the question with four servos running simultaneously, up to 0.5 V of the supply can be lost in the switching harness alone. Over time, as the connectors and switch contacts become worn and dirty, things can only get worse. It is possible to get around the weaknesses of the mechanical system using modern electronics. In this circuit we use a MOSFET as the switching element, giving an 'on' resistance (R_{DSON}) of 0.025 mΩ. It would be practically impossible to achieve such a low value in a mechanical system. The circuit is switched on and off using two tiny pushbuttons, which have considerably less impact on the appearance of a model than a big ugly mechanical switch.

A further advantage is that the supply voltage is continuously monitored, with a permanent indication of any interruption in the supply — and not a microcontroller in sight! The circuit's status is shown by two light-emitting diodes, so that the user can see what is going on at all times.

Requirements

The electronic switching element, which sits between the battery and the receiver and servos, must:

1. be capable of operation at supply voltages as low as 4.5 V;

2. have as low an 'on' resistance as possible;

3. be able to handle currents of up to 5 A without difficulty.

We can satisfy all these requirements using MOSFETs, which are available in a wide range of power ratings. Because we have to deal with low supply voltages of around 4.5 V, the so-called 'logic level' types are the most suitable. At these voltages, ordinary MOSFETs operate more as variable resistors rather than as switches, which leads to a greater voltage drop and considerable power dissipation in the device.

Here we have decided to use the type SUD45P03-15A, a P-channel MOSFET made by Vishay (formerly Siemens). This device is available in a TO-252, or 'DPAK', package and can handle currents as high as 10 A without difficulty. This makes it ideal for use as a power switch in a model. Its 'on' resistance R_{DSON} is 0.025 mΩ, which means that the voltage dropped across it will be negligible even at high currents.

There are many other types that have the above properties which could be used instead, as a brief glance through the catalogues of component suppliers will reveal.

Switching on and off

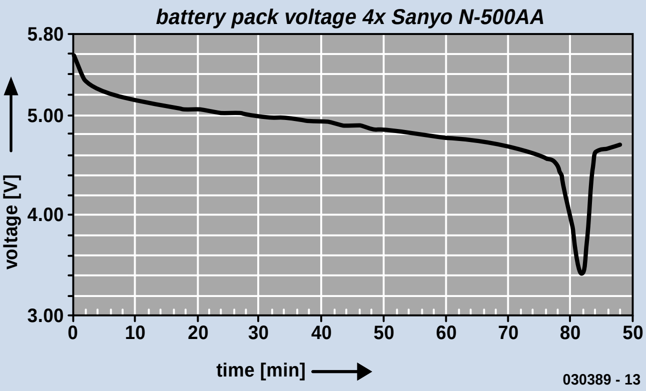
The circuit diagram of the electronic switching system is shown in **Figure 1**. The transistor conducts when its gate is taken to ground by T4. In the non-conducting ('off') state, the gate is taken to a definite (high) voltage level by R8. Green light-emitting diode D2 indicates when the circuit is in the 'on' state.

The circuit is switched to the 'on' state by a brief press on pushbutton S1. This takes the base of T5 to ground, and T5 and T3 conduct. Capacitor C2 charges up and, after a short time, provides a high enough voltage to switch transistor T4. This now takes over the job of pushbutton S1, and so the circuit remains in the 'on' state, even if the user releases the pushbutton.

C2 also allows the circuit to retain its state across brief interruptions of the power supply. When charged, it can supply enough current to the base of T4 to cover an interruption of several seconds. This behaviour can be demonstrated by disconnecting the

Batteries in RC models

When considering a voltage monitoring circuit, it is worth looking at the behaviour of a typical battery in a model. A few details become apparent when the discharge curve is studied carefully. First, the open-circuit voltage of the battery, when fully charged, is around 5.6 V. Under load this falls relatively quickly to around 5 V, where it remains for some time. After a certain discharge time (here approximately 76 minutes) the curve falls off sharply, indicating that the battery is almost completely flat. For a modeller it is important to know, before making a run, that there is sufficient charge remaining in the battery for the receiver to operate correctly.



Discharge curve at 300 mA for a four-cell NiCd battery (Sanyo type N-500AA)

battery terminals briefly and then reconnecting them: the green light-emitting diode lights again immediately, without the need to press the button. D3 prevents C2 from discharging rapidly via R11.

The circuit is switched to the 'off' state by pressing pushbutton S2. C2 is discharged and the base of T4 goes to ground potential. T4 stops conducting and then so does the MOSFET T3, since the voltage at its gate is no longer negative with respect to that at its source connection. Resistor R11 prevents a discharged C2 from being charged by leakage currents through T5.

Voltage monitoring

Many ways of monitoring the battery voltage in a remote-controlled model have been proposed. In December 2001 we presented a voltage tester circuit based on an LM3914 that showed the measured voltage on a row of ten LEDs. A disadvantage of that circuit was that the lowest measured voltage was not permanently recorded or displayed.

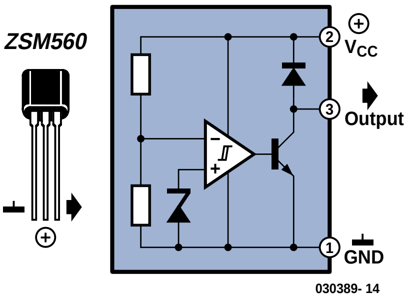


Figure 2. Internal circuit of the ZSM560 reset IC.

In this circuit the battery voltage is monitored using a so-called 'reset IC' (**Figure 2**), a device which is normally used to provide a reset signal to a microcontroller if the supply voltage falls below a certain threshold. There are many variations available on this theme, the chief difference between devices being in their threshold voltage. If a different threshold value is required, IC1 can be replaced by an appropriate substitute. Make sure, however, that the device has an open-collector output.

Essentially, a reset IC consists of a comparator and a reference voltage generator. The comparator switches when the voltage produced by the integrated potential divider, which consists of two resistors, falls below that produced by the reference generator. The transistor connected to the output of the comparator provides an open-collector output which pulls the output pin low when it is active.

The most important characteristics of the Zetex ZSM560 are as follows:

Maximum supply voltage:	*6.5 V*
Threshold voltage:	*4.6 V ± 0.1 V*
Hysteresis:	*20 mV typical*
Current consumption:	*135 mA typical*
Maximum output sink current:	*60 mA*

The reset IC used switches within microseconds and is therefore fast enough to detect reliably even the briefest supply excursions that go below the 4.6 V threshold. Unfortunately, the output goes inactive again once the supply voltage goes back above the threshold: it has no memory function. Here, this function is provided instead by a 'classical' (i.e. microcontroller-free) circuit, connected to the output of the device.

The memory circuit is essentially the same as that around the main supply switch T3. In this case the reset IC takes the place of the 'on' pushbutton, its output taking the base of T2 to ground when the supply voltage goes below the threshold. This drives T2, and red light-emitting diode D1 lights, signalling to the user that the supply voltage has fallen below 4.6 V. The user should then charge the battery (or possibly check the battery connections).

Construction and use

Construction of the electronic switching system should not present any difficulties. Since the space available in models can vary, we have not provided a printed circuit board layout. The circuit can instead be built on a piece of perforated board cut to a suitable size for the particular application. Ensure that the capacitors and transistors are correctly oriented. The MOSFET is soldered as an SMD device: first tin one pad, then put the transistor in place and solder one lead to the pad. Finally the other two leads can be soldered. Use reasonably thick wire to connect to the battery and to the receiver, since it will have to carry currents of 1 A or more. Precious millivolts of voltage drop can be lost if wire that is too thin is used.

In use, the switching system is very straightforward. Simply connect up the battery and the receiver, and then press the 'on' pushbutton. The green light-emitting diode should light. If the red light-emitting diode does not light, then the model is ready for a run. The circuit is switched off with a brief press of the 'off' pushbutton.

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